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FLOOD INSURANCE STUDY

ORIGINAL

TOWN OF WESTBROOK, CONNECTICUT
MIDDLESEX COUNTY

FEBRUARY 19, 1986

Federal Emergency Management Agency

COMMUNITY NUMBER - 090070

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Exhibit 2 - Flood Boundary and Floodway Map Index
Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index
Flood Insurance Rate Map

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FLOOD INSURANCE STUDY
TOWN OF WESTBROOK, CONNECTICUT

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the Town of Westbrook, Middlesex County, Connecticut, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in their efforts to promote sound flood plain management. Minimum flood plain management requirements for participation in the National Flood Insurance Program are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses in this study represent a revision of the original analyses performed by CE Maguire, Inc., for the Federal Emergency Management Agency (FEMA), under Contract No. H-4560. The original work was completed in November 1978. The updated version was prepared by the New England Division of the U. S. Army Corps of Engineers for FEMA, under Inter-Agency Agreement No. EMW-E-0941. This work was completed in October 1983.

1.3 Coordination

On August 12, 1982, the detailed analyses were discussed at an initial Consultation and Coordination Officer's (CCO) meeting attended by representatives of FEMA, the Town of Westbrook, and the New England Division of the U. S. Army Corps of Engineers (COE - the study contractor).

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The Soil Conservation Service (SCS), the Connecticut Department of Environmental Protection, the Connecticut Department of Transportation, the U. S. Geological Survey (USGS), the Connecticut River Estuary Regional Planning Agency, the American Red Cross, the Connecticut Water Company, and the Westbrook Historical Society were contacted for various types of information. During the course of the initial work, specific information on peak discharge-frequency relationships, flood control channel and dam improvements, previous flood hazard evaluations, recent and impending flood plain development, and the extent of historic flooding were obtained, reviewed, and discussed with various community and state officials and local residents.

On February 6, 1985, the results of the study were reviewed at a final CCO meeting held with representatives of FEMA, the town, and the study contractor.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Town of Westbrook, Middlesex County, Connecticut. The area of study is shown on the Vicinity Map (Figure 1).

The Patchogue River from Boston Post Road (U. S. Route 1) to the Connecticut Turnpike (Interstate 95), the entire length of the Menunketesuck River within the corporate limits, and the Falls River from the downstream corporate limits to Messerschmidt Pond Dam were studied by detailed methods. Tidal flooding including its wave action from Long Island Sound was also studied by detailed methods. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction through October 1988.

Dee Pond, Johnson Pond, McVeagh Pond, Messerschmidt Pond, Rintoul Pond, Vincent Pond, Wrights Pond, Boones Brook, Plane Brook, Trout Brook, Mine Swamp, several depressed areas, and the remaining portion of the Patchogue River were studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the Town of Westbrook.

2.2 Community Description

The Town of Westbrook is located in the southern portion of Middlesex County in south-central Connecticut. It is bordered by the Town of Clinton to the west, the Towns of Deep River and Essex to the north, the

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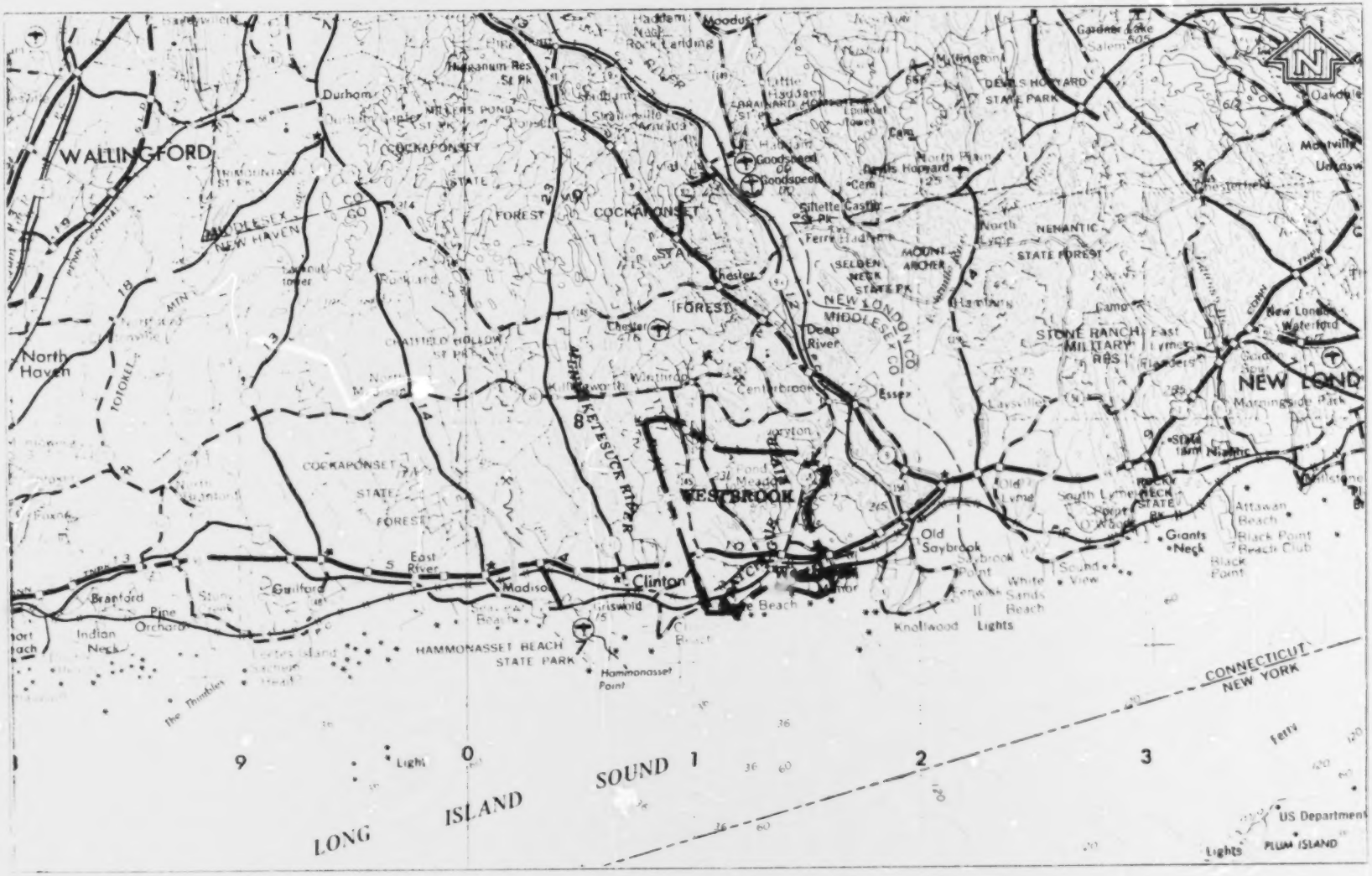

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

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Town of Old Saybrook to the east, and Long Island Sound to the south. The total land area contained within the corporate limits is 16.2 square miles. The population of Westbrook was approximately 4,800 in 1976, for a population density of approximately 296 persons per square mile. During the periods from 1950 to 1960 and from 1960 to 1970, the population of the town increased by 55 percent and 59 percent, respectively (Reference 1).

The topography of Westbrook is mainly flat lowland areas in the southern portion and rolling hills in the northern area. Elevations range from sea level along the coastline to 250-310 feet in many of the hills in the northwestern corner of the town.

The predominant soil type along the Patchogue River is swamp sediment consisting of undecomposed to partly decomposed organic matter mixed with sand, silt, and clay. In the areas where the river traverses Interstate 95, Boston Post Road, and Conrail, deposits of artificial fill are evident. Along the west bank at different locations, glacial ground moraines and outwash sediments are encountered. The ground moraines consist of till, which is a non-sorted, non-stratified deposit of glacial debris ranging from clay-size particles to large boulders. The outwash sediments consist of sand and gravel deposited by glacial meltwater streams. On the east bank at various scattered points, the river passes through deposits of end moraine, which is a soil deposit consisting of till and stratified drift. The stratified drift consists of sand and gravel in varying amounts with occasional concentrations of boulders.

Soils in the area of the Menunketesuck River are primarily classified as swamp sediment. Areas of artificial fill are encountered where the river crosses Conrail and the Boston Post Road.

In the vicinity of the Westbrook-Clinton town boundary, there are a few deposits of ice-contact stratified drift, which consists of poorly sorted sand, gravel, silt, and clay deposited by the melting glacier ice. A deposit of till is also evident in this area. An area of bedrock exposure is situated just to the east and is completely exposed or thinly covered by till or rock slide. In the vicinity of Boston Post Road, small areas of end moraine and outwash sediment are evident on the west bank.

The two major soil types along Long Island Sound are beach sand and gravel and artificial fill. In the vicinity of Money Point, there is an intrusion of till.

The flood plains within the town consist generally of sparse residential development with some light commercial development adjacent to Boston Post Road. Tidal wetlands comprise a large portion of the flood plains.

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The climate of the region is characterized by moderately warm summers with temperatures averaging 70.1 degrees Fahrenheit (°F). The winters are cool with temperatures averaging 32.4°F. The average annual precipitation is approximately 49.8 inches and is evenly distributed throughout the year (Reference 2).

Westbrook has been growing steadily over the past several decades. As the population has increased, residential development has spread north from the shore, from Boston Post Road to Interstate 95. Economic activity is largely confined to the southern portion of the town along Boston Post Road. Only sparse development has occurred north of Interstate 95, leaving that area predominantly rural in nature. Approximately 71 percent of the town's land is in rural and natural resource areas, such as the Cockaponset State Forest (Reference 3). Industrial development is limited due to the town's orientation toward fishing and recreational activities.

2.3 Principal Floods Problems

All areas adjacent to streams in Westbrook are subject to flooding. The Westbrook coastline is subject to tidal flooding from coastal storms pushed north by air currents.

Extremely high tide levels induced by wind-driven waves accompanying hurricanes and coastal storms are the principal causes of flooding on the coastline. The floods of record in Westbrook occurred on September 21, 1938, and August 31, 1954. The recorded elevation for the 1938 flood at Westbrook was 9.4 feet, with an estimated recurrence interval of 50 years; the elevation for the 1954 flood was 9.2 feet, with an estimated recurrence interval of 42 years (Reference 4). The principal damage from these storms has been the destruction and loss of development in the low coastal areas and tidal estuaries adjacent to Long Island Sound. During the September 1938 storm, floodwaters from the Menunketesuck River overtopped the State Route 145 bridge by 8 to 10 inches (Reference 5).

In January 1978, a winter rainstorm caused severe flooding along the streams within Westbrook. Due to a combination of frozen ground, snowmelt, high tides, and increased development along the streams, this flood was extensive and forced many families to evacuate their homes.

Figures 2 through 6 show potential 100- and 500-year flood heights at several locations on the Patchogue and Menunketesuck Rivers within Westbrook.

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Figure 2 - Potential 100- and 500-year flood heights on the Menunketesuck River at Boston Post Road (U. S. Route 1), looking east.

Figure 3 - Potential 100- and 500-year flood heights on the Menunketesuck River at State Route 145 (Old Clinton Road), looking north.

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Figure 4 - Patchogue River, expected 500-year flood level on U.S. Route 1 (Boston Post Road) - looking northeast.

Figure 5 - Patchogue River, expected 100- and 500-year flood levels on Wesley Avenue - looking north.

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Figure 6 - Potential 100- and 500-year flood heights on the Patchogue River at State Route 145 (Old Clinton Road), looking northeast.

2.4 Flood Protection Measures

Westbrook formed a Harbor Commission in 1972 to regulate and control coastal development along the coastline with full regard for the protection and preservation of the natural resources of the town. In 1973, Westbrook formed an Inland Wetland Watercourse Commission, authorized by the Board of Selectmen in accordance with the provisions of the Inland Wetland and Watercourses Act of the Connecticut General Statutes. The primary function of the commission is to protect the public's interests by the preservation and protection of the wetlands and watercourses within the town from random, undesirable and unregulated uses, disturbance or destruction.

From field investigations and conversations with various town officials, it is estimated that approximately 70 percent of the Westbrook coastline has some type of seawall protection, the majority of which is privately owned. There are no existing or planned flood protection structures along the Patchogue and Menunketesuck Rivers.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected

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to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency and peak elevation-frequency relationships for the flooding sources studied in detail affecting the community.

A regional frequency method was used to compute peak discharges for the Patchogue and Menunketesuck Rivers (Reference 6). Due to the possibility of a large standard error in this method, a comparison of discharge computations was performed. A rainfall-runoff technique based on a synthetic triangular unit hydrograph and SCS methodology were utilized to assist in the adoption of discharges for various frequencies in a smooth curve (References 7 and 8).

There are no streamflow records for the Falls River. The East Branch Eightmile River, a gaged stream with similar hydrologic characteristics, is located 5 miles northeast of Essex, Connecticut. The East Branch Eightmile River has a drainage area of 22.3 square miles. Discharge frequencies for the East Branch Eightmile River at North Lyme were developed by a statistical analysis of its 45 years of streamflow records using a log-Pearson Type III distribution and including the estimated recent June 1982 flood peak (Reference 9). The resulting peak discharges for the 10-, 50-, 100-, and 500-year frequency floods were used to compute estimated Falls River flows at Falls River Pond Dam (drainage area 17.2 square miles) by direct drainage area ratio. Flows were developed at other upstream locations on the Falls River by drainage area ratio to the 0.7 exponential power.

A summary of drainage area-peak discharge relationships for the Patchogue, Menunketesuck, and Falls Rivers is shown in Table 1, "Summary of Discharges."

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TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
PATCHOGUE RIVER					
At Boston Post Road	7.53	540	920	1,100	1,600
At Interstate 95	6.52	486	827	989	1,439
MENUNKETESUCK RIVER					
At Boston Post Road	17.39	1,276	1,868	2,123	2,842
Just downstream of the confluence of Gatchen Creek	16.74	1,244	1,820	2,069	2,770
At Old Clinton Road	15.22	1,166	1,706	1,940	2,597
FALLS RIVER					
At the outlet of Wrights Pond	5.0	480	860	1,080	2,130
At the outlet of Messerschmidt Pond	4.0	410	740	930	1,830

Stillwater elevations for Long Island Sound were developed by Dewberry & Davis by adjusting elevations contained in the COE publication, Tidal Flood Profiles for the New England Coastline (References 10 and 11). The adjustment was made using a New London, Connecticut, tidal gage analysis and the profiles for the 1938 and 1954 storms (Reference 12).

Stillwater elevations for the Menunketesuck River upstream of the Conrail bridge were determined by a routing analysis using information from the COE Interim Memo No. COE 2 (Reference 4).

The stillwater elevations for the 10-, 50-, 100-, and 500-year floods have been determined for Long Island Sound and the Menunketesuck River and are summarized in Table 2, "Summary of Stillwater Elevations."

TABLE 2 - SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
LONG ISLAND SOUND				
Entire shoreline within Westbrook	7.6	9.4	10.4	12.4
MENUNKETESUCK RIVER				
Upstream of Conrail bridge	5.5	6.2	6.7	12.4

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The stillwater elevation is the elevation of the water due solely to effects of the astronomical tides, storms surges, and wave setup on the water surface. The inclusion of wave heights, which is the distance from the trough to the crest of the wave, increases the water-surface elevations. The height of a wave is dependent upon wind speed and its duration, depth of water, and length of fetch. The wave crest elevation is the sum of the stillwater elevation and the portion of the wave height above the stillwater elevation. Wave heights and corresponding wave crest elevations were determined using the National Academy of Sciences (NAS) methodology (Reference 13).

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the riverine sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Cross-section data for the backwater analyses were obtained by field measurements and from topographic maps compiled from aerial photographs (Reference 14). When available, bridge plans were utilized to obtain elevation data and structural geometry. All bridges and culverts for which plans were unavailable or out of date were field surveyed.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

For the Patchogue River, no profile is shown since the stream is entirely affected by backwater from Long Island Sound.

Water-surface elevations of floods of the selected recurrence intervals were computed using the COE HEC-2 step-backwater computer program (Reference 15). Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals. Starting water-surface elevations for the Patchogue and Menunketesuck Rivers were obtained using the mean high-water levels on Long Island Sound. Starting water-surface elevations for the Falls River were obtained from the Flood Insurance Study for the Town of Essex (Reference 16).

Roughness coefficients (Manning's "n") used in the hydraulic computations were estimated by field inspection at each cross section. The channel "n" value for the Patchogue River was 0.025, and the overbank "n" values ranged from 0.050 to 0.100. For the Menunketesuck River, the channel "n" values ranged from 0.025 to 0.045, and the overbank "n" values ranged from 0.045 to 0.150. The channel "n" value for the Falls River was 0.050, and the overbank "n" value was 0.080.

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The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Hydraulic analyses of the shoreline characteristics of the tidal flooding sources studied in detail were carried out to provide estimates of wave heights and corresponding wave crest elevations of floods of the selected recurrence intervals along each of the shorelines.

Areas of coastline subject to significant wave attack are referred to as coastal high hazard zones. The COE has established the 3-foot breaking wave as the criterion for identifying the limit of coastal high hazard zones (Reference 17). The 3-foot wave has been determined as the minimum size wave capable of causing major damage to conventional wood frame or brick veneer structures. This criterion has been adopted by the FEMA for the determination of V-zones.

The methodology for analyzing wave heights and corresponding wave crest elevations was developed by the NAS (Reference 13). The methodology is based on three major concepts.

First, a storm surge on the open coast is accompanied by waves. The maximum height of these waves is related to the depth of water by the following equation:

$$H_b = 0.78d$$

where H_b is the crest to trough height of the maximum or breaking wave and d is the stillwater depth. The elevation of the crest of an unimpeded wave is determined using the equation:

$$Z_w = S_* + 0.7H_* = S_* + 0.55d:$$

where Z_w is the wave crest elevation, S_* is the stillwater elevation at the site, and H_* is the wave height at the site. The 0.7 coefficient is the portion of the wave height which reaches above the stillwater elevation. H_b is the upper limit for H_*.

The second major concept is that the breaking wave height may be diminished by dissipation of energy by natural or man-made obstructions. The wave height transmitted past a given obstruction is determined by the following equation:

$$H_t = BH_i$$

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where H_t is the transmitted wave height, H_i is the incident wave height, and B is a transmission coefficient ranging from 0.0 to 1.0. The coefficient is a function of the physical characteristics of the obstruction. Equations have been developed by the NAS to determine B for vegetation, buildings, natural barriers such as dunes, and man-made barriers such as breakwaters and seawalls (Reference 13).

The third concept deals with unimpeded reaches between obstructions. New wave generation can result from wind action. This added energy is related to distance and mean depth over the unimpeded reach.

These concepts and equations were used to compute wave heights and wave crest elevations associated with the 100-year storm surge. Accurate topographic, land-use, and land cover data are required for the wave height analysis. Maps of the shoreline areas at a scale of 1:4,800 with a contour interval of 5 feet were used for the topographic data (Reference 18). The land-use and land cover data were obtained from aerial photographs (Reference 19).

Wave heights were computed along transects which were located perpendicular to the average mean shoreline. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, the transects were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Figure 7 illustrates the location of the transects for the community and Table 3 provides a physical description of the area along the shoreline represented by each transect.

TABLE 3 - TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet) Stillwater 100-year	Elevation (feet) Maximum Wave Crest 100-year
No. 1	Western corporate limits to Grove Beach Road, extended	10.4	16
No. 2	Grove Beach Road, extended, to Menunketesuck Road, extended	10.4	16
No. 3	Menunketesuck Road, extended, to Grove Beach Point	10.4	16

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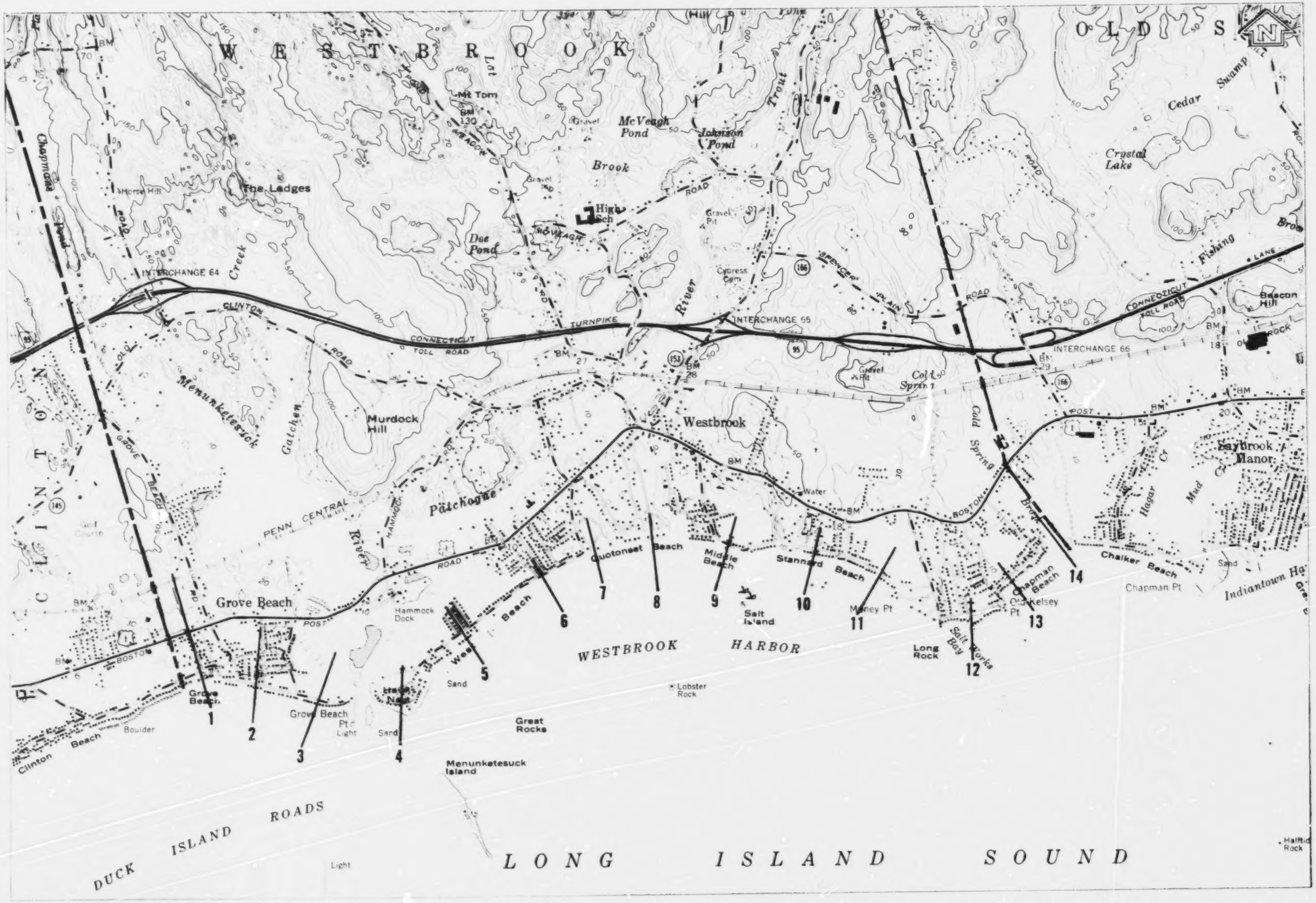

APPROXIMATE SCALE
6000 FEET
4000
2000
0
2000

TRANSECT LOCATION MAP

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

FIGURE 7

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TABLE 3 - TRANSECT DESCRIPTIONS - continued

Transect	Location	Elevation (feet) Stillwater 100-year	Maximum Wave Crest 100-year
No. 4	Grove Beach Point to Striper Avenue, extended	10.4	16
No. 5	Striper Avenue, extended, to Tarpon Avenue, extended	10.4	16
No. 6	Tarpon Avenue, extended, to Seaside Avenue	10.4	16
No. 7	Seaside Avenue to Kingsfisher Lane, extended	10.4	16
No. 8	Kingsfisher Lane, extended, to Gerard Avenue, extended	10.4	16
No. 9	Gerard Avenue, extended, to Economy Drive, extended	10.4	16
No. 10	Economy Drive, extended, to Maple Avenue, extended	10.4	16
No. 11	Maple Avenue, extended, to Salt Works Road, extended	10.4	16
No. 12	Salt Works Road, extended, to Kelsey Point Road, extended	10.4	16
No. 13	Kelsey Point Road, extended, to Chapman Beach Road, extended	10.4	16
No. 14	Chapman Beach Road, extended, to eastern corporate limits	10.4	16

Along each transect, wave heights and wave crest elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. Wave heights were calculated to the nearest 0.1 foot, and wave crest elevations were determined at whole-foot increments. The calculations were carried inland along the transect until the wave crest elevation was permanently less than 0.5 foot above the stillwater elevation or the coastal flooding met another flood source (i. e. riverine) with an equal water-surface elevation. The results of the calculations are accurate until local topography, vegetation, or cultural development of the community undergo any major changes.

Figure 8 represents a sample transect which illustrates the relationship between the stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the V zone boundary. Actual wave conditions in Westbrook may not include all the situations illustrated in Figure 8.

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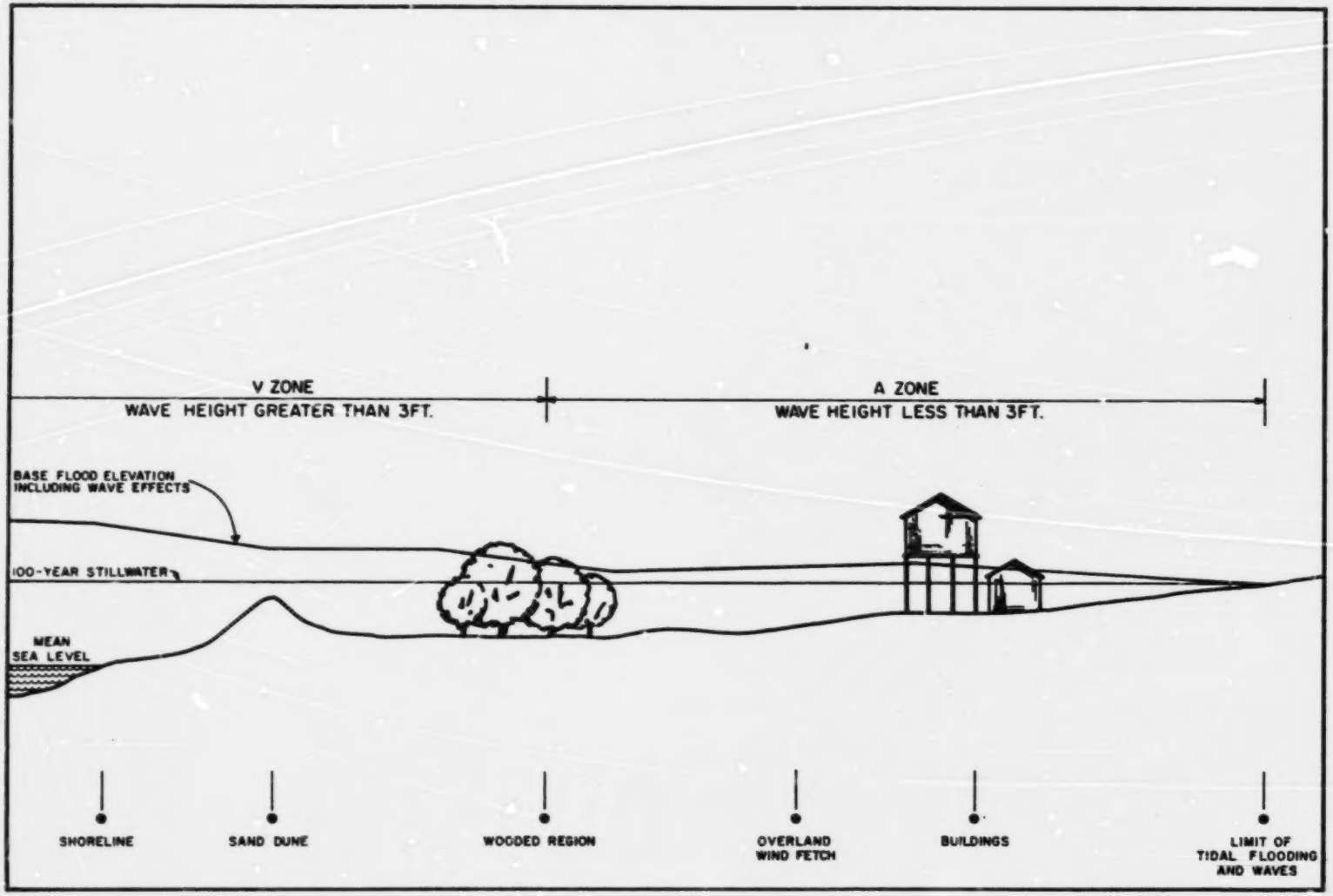

FIGURE 8
TYPICAL TRANSECT SCHEMATIC

The maximum wave crest elevation from Long Island Sound is 16 feet. Waves greater than 3 feet affect the shoreline of the town but do not propagate inland to a significant extent due to the rise in ground elevation, with the exception of the marsh area at the eastern end of the town and the Grove Beach area. Waves greater than 3 feet from Long Island Sound are reduced by rising ground elevations and development along Westbrook Harbor as far east as Chapman Beach. East of Chapman Beach, waves greater than 3 feet propagate through the adjacent Cold Spring Brook marsh area. At the western end of the town, waves penetrate the low-lying Grove Beach area. Waves less than 3 feet propagate into the town in several areas, including some low-lying areas of the Patchogue and Menunketesuck Rivers and at Stannard, Middle, Quotenset, and West Beaches. These waves are diminished by development, vegetation, and the rise in ground elevation.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For riverine streams, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps (References 14 and 20).

For tidal areas without wave action, the 100-year and 500-year boundaries were delineated using the topographic maps referenced above (Reference 18). For the tidal areas with wave action, the flood boundaries were delineated using the elevations determined at each transect; between transects, the boundaries were interpolated using engineering judgment, land-cover data, and the topographic maps referenced above (Reference 18). The 100-year flood plain was divided into whole-foot elevation zones based on the average wave envelope elevation in that zone. Where the map scale did not permit these zones to be delineated at one foot intervals, larger increments were used.

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For the areas studied by approximate methods, the boundary of the 100-year flood was delineated using the original Flood Insurance Study for Westbrook (Reference 21).

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 4).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown. Portions of the floodway widths for the Menunketesuck River and the Falls River extend beyond the corporate limits.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Patchogue River								
A	0.017	80	595	1.8	10.4	2.5[2]	2.5	0.0
B	0.034	67	435	2.5	10.4	2.5[2]	2.5	0.0
C	0.213	80	549	2.0	10.4	2.6[2]	2.6	0.0
D	0.593	60	340	3.2	10.4	2.8[2]	2.8	0.0
E	0.982	70	432	2.5	10.4	3.4[2]	3.4	0.0
F	1.080	100	669	1.6	10.4	3.5[2]	3.5	0.0
G	1.106	60	442	2.5	10.4	4.7[2]	4.7	0.0
H	1.272	50	386	2.8	10.4	4.8[2]	4.8	0.0
I	1.476	60	532	2.1	10.4	4.9[2]	5.0	0.1
J	1.538	110	1,021	1.1	10.4	5.0[2]	5.1	0.1
K	1.566	40	379	2.9	10.4	5.5[2]	5.5	0.0
L	1.663	50	388	2.8	10.4	5.5[2]	5.5	0.0
M	1.704	50	355	3.1	10.4	5.6[2]	5.7	0.1
N	1.810	60	384	2.9	10.4	5.8[2]	5.8	0.0
O	1.916	60	417	2.6	10.4	5.9[2]	6.0	0.1
Menunketesuck River								
A	0.009	233	1,981	1.1	10.4	2.5[2]	2.5	0.0
B	0.149	140	1,245	1.7	10.4	2.5[2]	2.5	0.0
C	0.419	360	2,475	0.9	10.4	2.6[2]	2.6	0.0
D	0.588	100	922	2.3	10.4	2.6[2]	2.6	0.0
E	0.612	73	437	4.9	6.7	3.2[2]	3.2	0.0

[1]Miles above U. S. Route 1

[2]Elevation computed without consideration of backwater from Long Island Sound

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

FLOODWAY DATA

PATCHOGUE RIVER, AND MENUNKETESUCK RIVER

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Menunketesuck River (continued)								
F	0.921[1]	150	1,004	2.1	6.7	4.3[4]	4.3	0.0
G	1.288[1]	60	574	3.6	6.7	5.1[4]	5.4	0.3
H	1.555[1]	70	720	2.9	6.7	5.7[4]	6.5	0.8
I	2.086[1]	175	1,570	1.3	6.7	6.1[4]	6.1	0.0
J	2.123[1]	90[3]	1,253	1.5	11.8	11.8	11.8	0.0
K	2.287[1]	110[3]	1,500	1.3	11.9	11.9	11.9	0.0
L	2.427[1]	150[3]	2,041	1.0	11.9	11.9	11.9	0.0
M	2.840[1]	160[3]	1,862	1.0	13.6	13.6	13.6	0.0
N	3.287[1]	245[3]	2,223	0.9	13.7	13.7	13.7	0.0
O	3.603[1]	35[3]	300	6.5	14.6	14.6	14.9	0.3
P	3.718[1]	90[3]	413	4.7	16.1	16.1	16.7	0.6
Q	3.748[1]	80[3]	613	3.2	18.7	18.7	18.8	0.1
Falls River								
A	29,280[2]	150	550	2.6	104.1	104.1	105.1	1.0
B	30,460[2]	100	412	3.5	108.7	108.7	109.4	0.7
C	31,520[2]	200	516	2.8	113.5	113.5	114.4	0.9
D	33,910[2]	130	1,098	1.3	126.1	126.1	127.0	0.9
E	34,489[2]	130	580	2.5	126.2	126.2	127.1	0.9
F	37,750[2]	200[3]	590	1.8	132.4	132.4	133.1	0.7

[1]Miles above U. S. Route 1

[2]Feet above Falls River Pond Dam

[3]This width extends beyond corporate limits

[4]Elevation computed without consideration of backwater from Long Island Sound

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

FLOODWAY DATA

MENUNKETESUCK RIVER, AND FALLS RIVER

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Patchogue River								
A	0.017	80	595	1.8	10.4	2.5[2]	2.5	0.0
B	0.034	67	435	2.5	10.4	2.5[2]	2.5	0.0
C	0.213	80	549	2.0	10.4	2.6[2]	2.6	0.0
D	0.593	60	340	3.2	10.4	2.8[2]	2.8	0.0
E	0.982	70	432	2.5	10.4	3.4[2]	3.4	0.0
F	1.080	100	669	1.6	10.4	3.5[2]	3.5	0.0
G	1.106	60	442	2.5	10.4	4.7[2]	4.7	0.0
H	1.272	50	386	2.8	10.4	4.8[2]	4.8	0.0
I	1.476	60	532	2.1	10.4	4.9[2]	5.0	0.1
J	1.538	110	1,021	1.1	10.4	5.0[2]	5.1	0.1
K	1.566	40	379	2.9	10.4	5.5[2]	5.5	0.0
L	1.663	50	388	2.8	10.4	5.5[2]	5.5	0.0
M	1.704	50	355	3.1	10.4	5.6[2]	5.7	0.1
N	1.810	60	384	2.9	10.4	5.8[2]	5.8	0.0
O	1.916	60	417	2.6	10.4	5.9[2]	6.0	0.1
Menunketesuck River								
A	0.009	233	1,981	1.1	10.4	2.5[2]	2.5	0.0
B	0.149	140	1,245	1.7	10.4	2.5[2]	2.5	0.0
C	0.419	360	2,475	0.9	10.4	2.6[2]	2.6	0.0
D	0.588	100	922	2.3	10.4	2.6[2]	2.6	0.0
E	0.612	73	437	4.9	6.7	3.2[2]	3.2	0.0

[1]Miles above U. S. Route 1

[2]Elevation computed without consideration of backwater from Long Island Sound

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

FLOODWAY DATA

PATCHOGUE RIVER, AND MENUNKETESUCK RIVER

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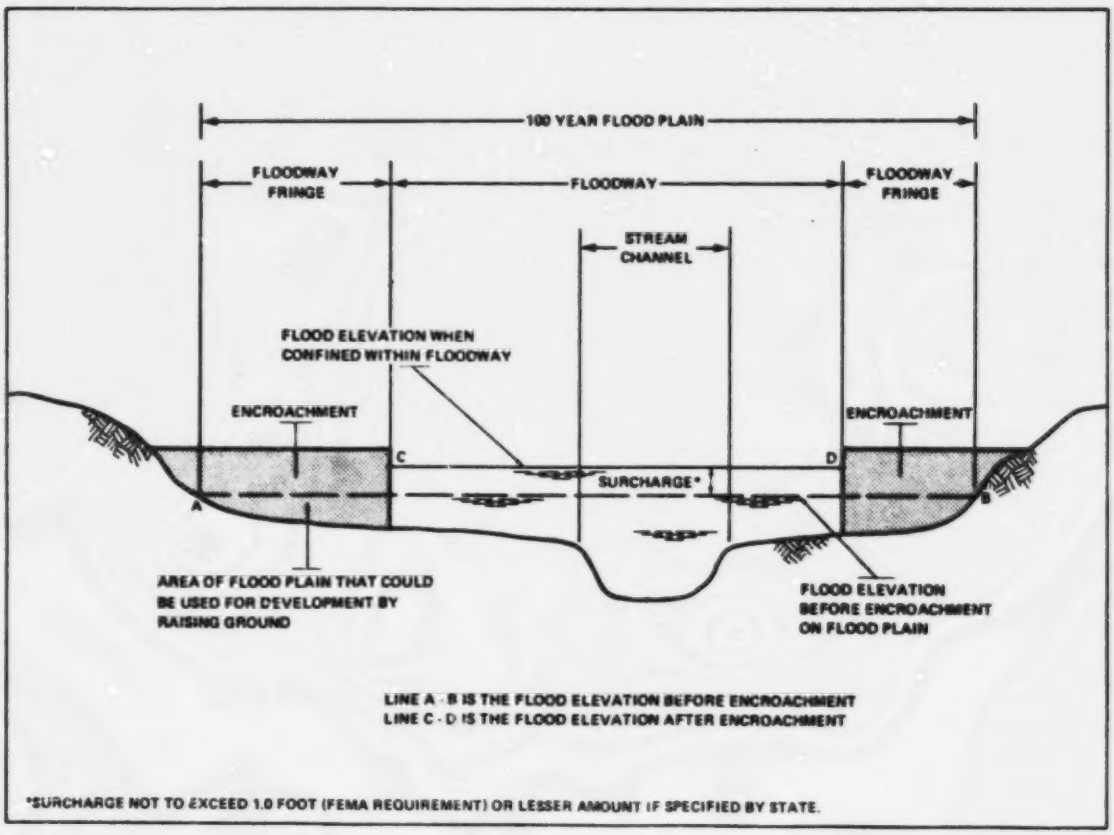
the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 9.


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FLOODWAY SCHEMATIC

Figure 9

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 4 for certain downstream cross sections of the Patchogue River and the Menunketesuck River are lower than the regulatory flood elevations in that area, which must take into account the 100-year flooding due to backwater from other sources.

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the

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determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail in the Town of Westbrook.

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following tabulation for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of the Town of Westbrook are shown on the Flood Profiles (Exhibit 1) and summarized in Table 5A.

In areas where wave height analyses were performed, reaches were determined for areas of the coastline, represented by a transect or group of transects, which have the same physical characteristics. For each transect the coastal high hazard zone (V zone) may be divided into two reaches to reflect those areas where wave runup is a dominant factor and those areas where wave runup does not dominate and elevations are determined by the wave height analysis. The reaches determined for the coastal flooding source of the Town of Westbrook are summarized in Table 5B.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10-

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Menunketesuck River							
Tidal Flooding	05	-1.2	-0.5	+8.5	010	A2	7
Reach 1	05	-2.0	-0.4	+0.8	020	A4	Varies
Reach 2	03	-1.1	-0.2	+1.4	010	A2	Varies
Falls River							
Reach 1	01,02	-1.9	-0.7	+1.5	020	A4	Varies
Reach 2	01	-1.1	-0.3	+1.3	010	A2	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

TABLE 5A

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

FLOOD INSURANCE ZONE DATA

MENUNKETESUCK RIVER, AND FALLS RIVER

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TABLE 5B - FLOOD INSURANCE ZONE DATA

Flooding Source	Stillwater Elevation 10-Year	100-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Long Island Sound					
Transects 1-7	7.6	10.4	045	V9	13-15
			035	A7	10-12
			025	A5	10
			030	A6	10
Transects 8-10	7.6	10.4	045	V9	13-15
			040	A8	10-12
Transects 11-14	7.6	10.4	045	V9	13-16
			035	A7	10-12
			030	A6	10

*Due to map scale limitations, base flood elevations shown on the FIRM represent average elevations for the zones depicted.

and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.

Zones A2, A4, A5, A6, A7, and A8: Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.

Zone V9: Special Flood Hazard Areas along coasts inundated by the 100-year flood that have additional velocity hazards associated with waves of 3-foot amplitude or greater; with base flood elevations shown, and zones subdivided according to FHFs.

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Zone B: Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding; not subdivided.

Flood elevation differences, FHFs, flood insurance zones, and base flood elevations for the flooding sources studied in detail in the community are shown in Tables 5A and 5B.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the Town of Westbrook is, for insurance purposes, the principal result of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the locations of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the National Flood Insurance Program.

6.0 OTHER STUDIES

Flood Insurance Studies for the Towns of Clinton, Old Saybrook, and Deep River have been completed (References 22, 23, and 24). The results of this study are in exact agreement with the results of the Clinton study. The boundaries between Westbrook and Old Saybrook do not match exactly at some points along the corporate limits. This difference could result from the fact that a transect was run along the corporate limits for the Westbrook study, thus giving elevations with wave heights. The analysis of the Falls River has not been updated in the Deep River study. Upon the revision of that study, the results of the Deep River and Westbrook studies will be in exact agreement.

The Flood Insurance Study for the Town of Essex is currently being prepared (Reference 16). The results of that study will be in exact agreement with the results of this study.

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7.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, Regional Director, Region I Office, J. W. McCormack Post Office and Courthouse Building, Room 462, Boston, Massachusetts 02109.

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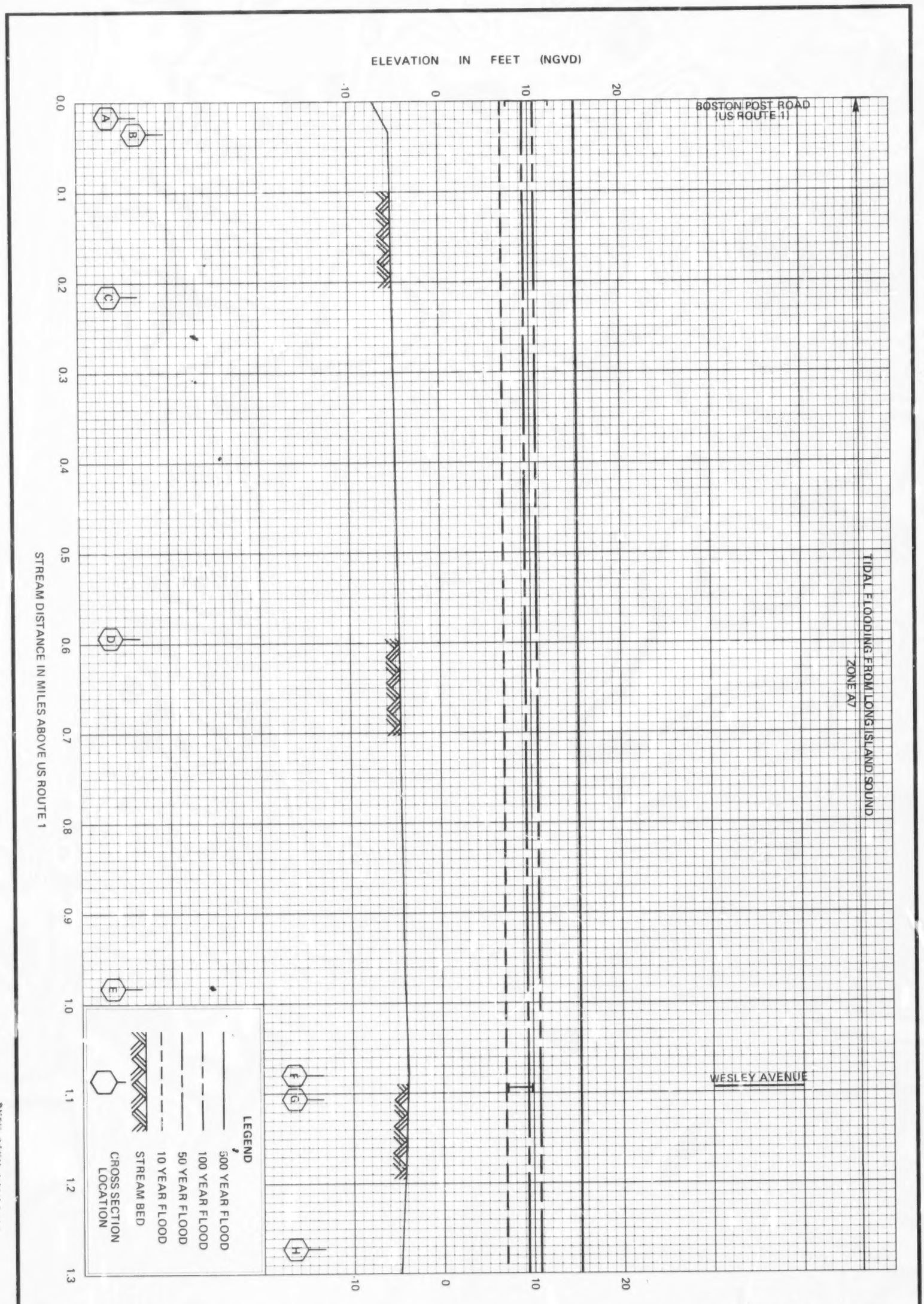

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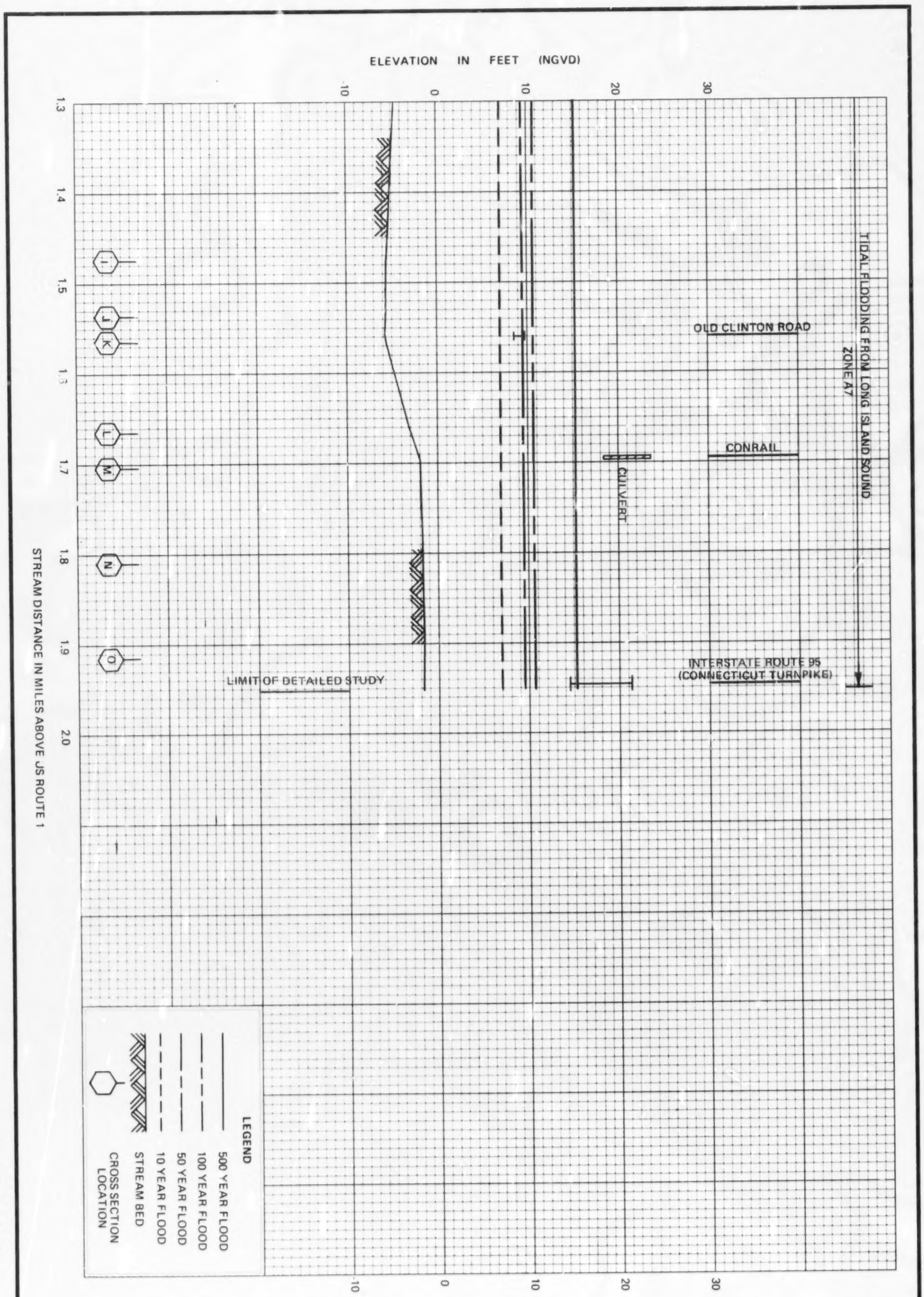

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

FLOOD PROFILES

PATCHOGUE RIVER

02P

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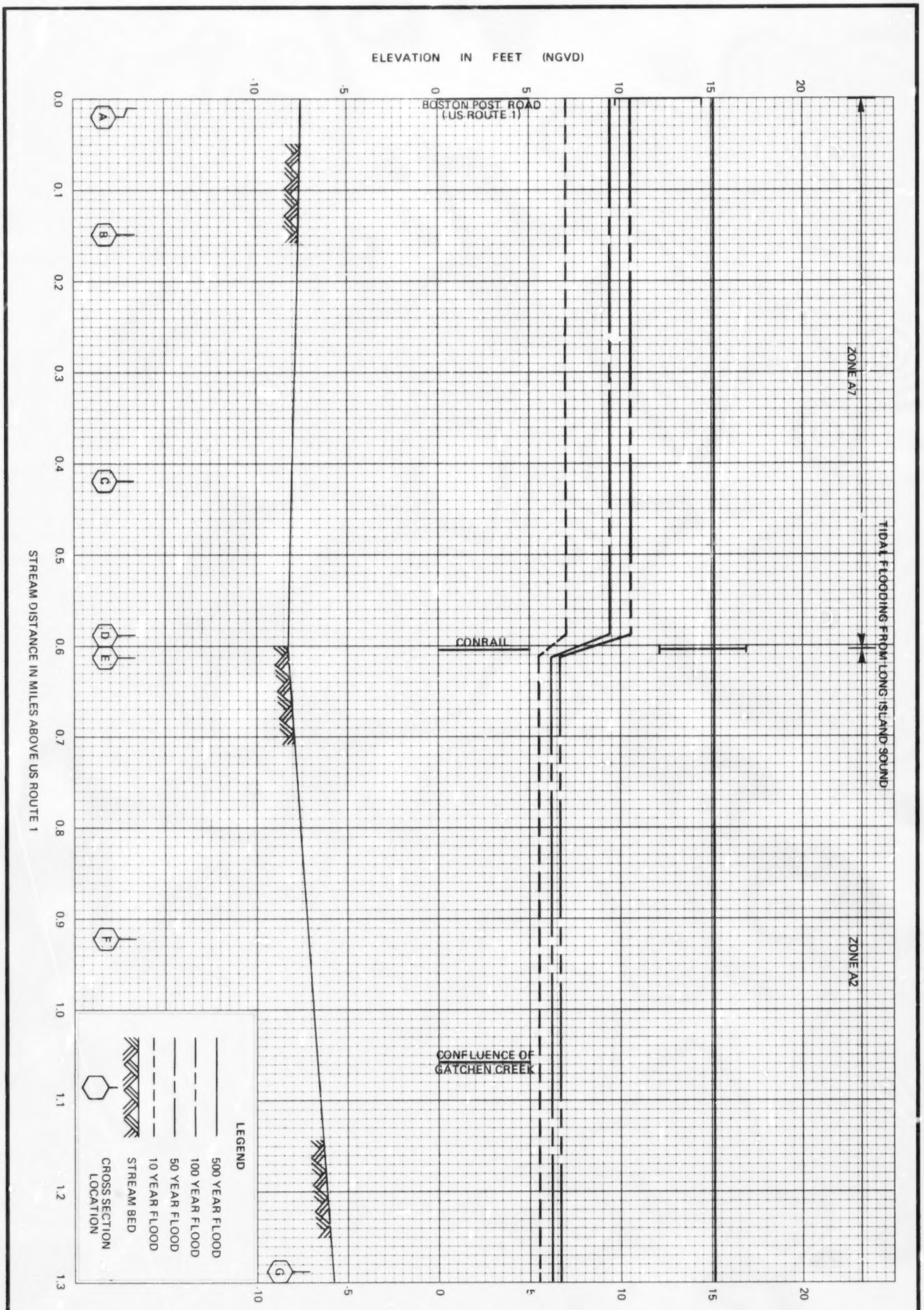

03P	FEDERAL EMERGENCY MANAGEMENT AGENCY **TOWN OF WESTBROOK, CT** (MIDDLESEX CO.)	**FLOOD PROFILES** **MENUNKETESUCK RIVER**

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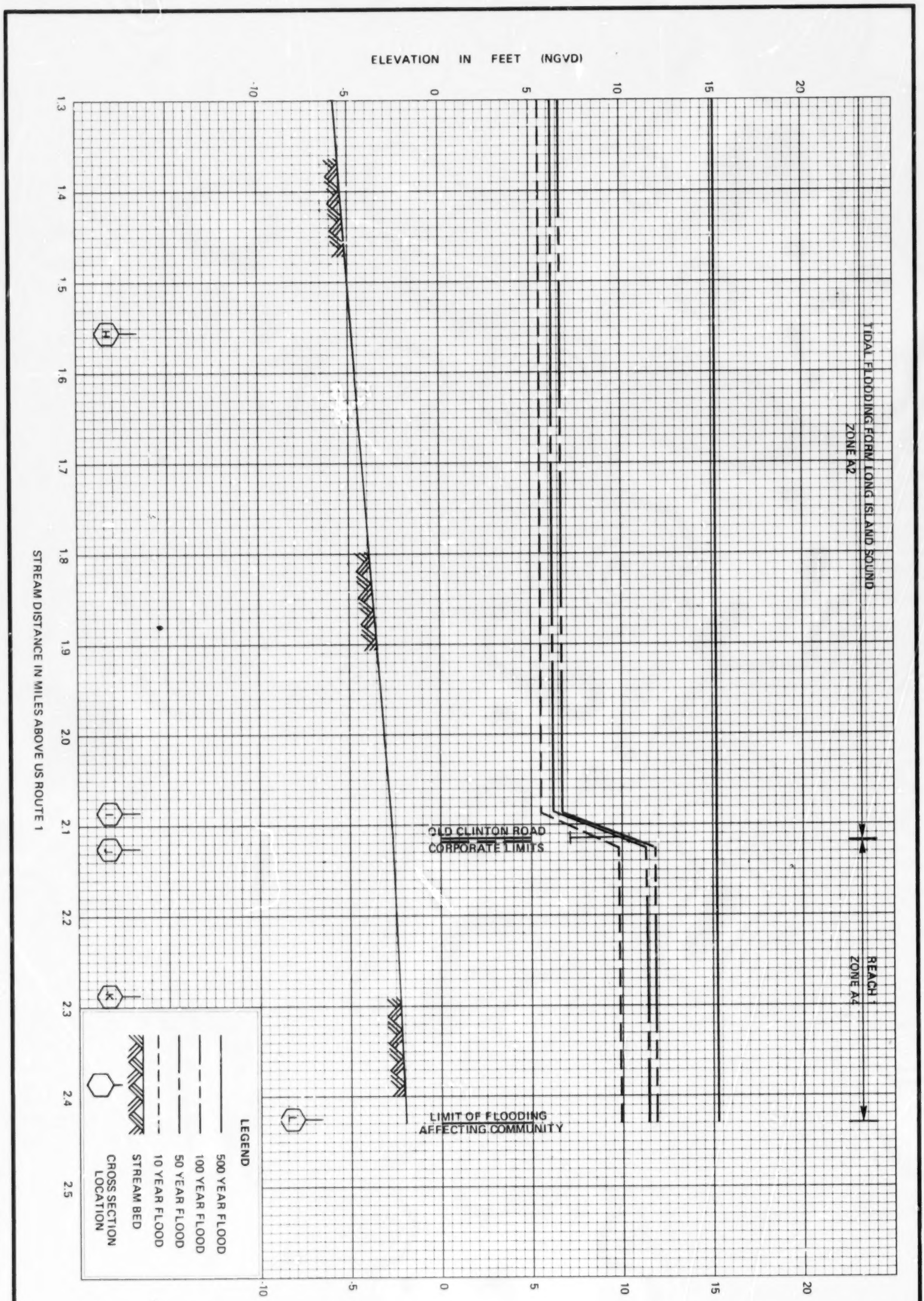

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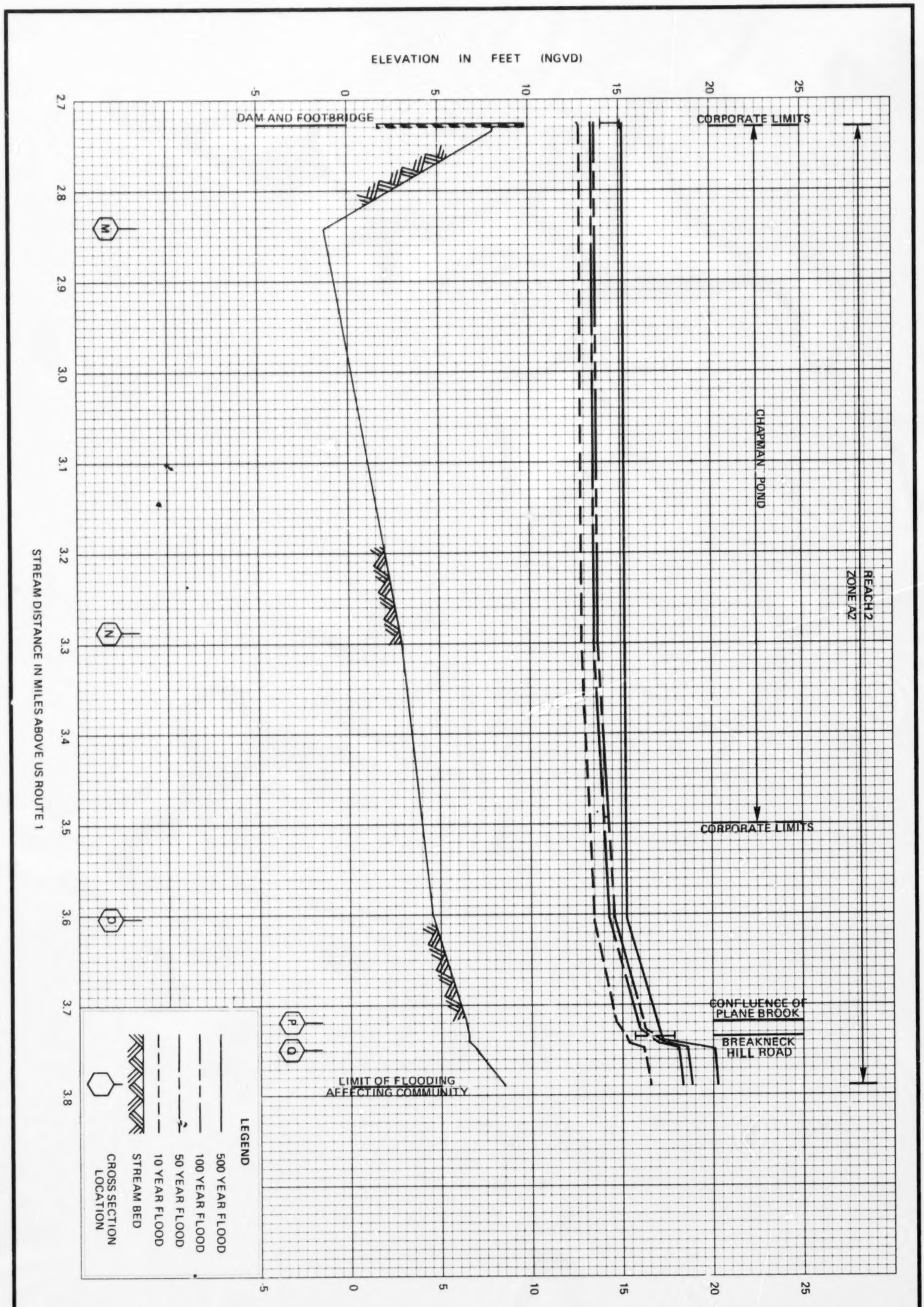

05P	FEDERAL EMERGENCY MANAGEMENT AGENCY **TOWN OF WESTBROOK, CT** (MIDDLESEX CO.)	**FLOOD PROFILES** **MENUNKETESUCK RIVER**

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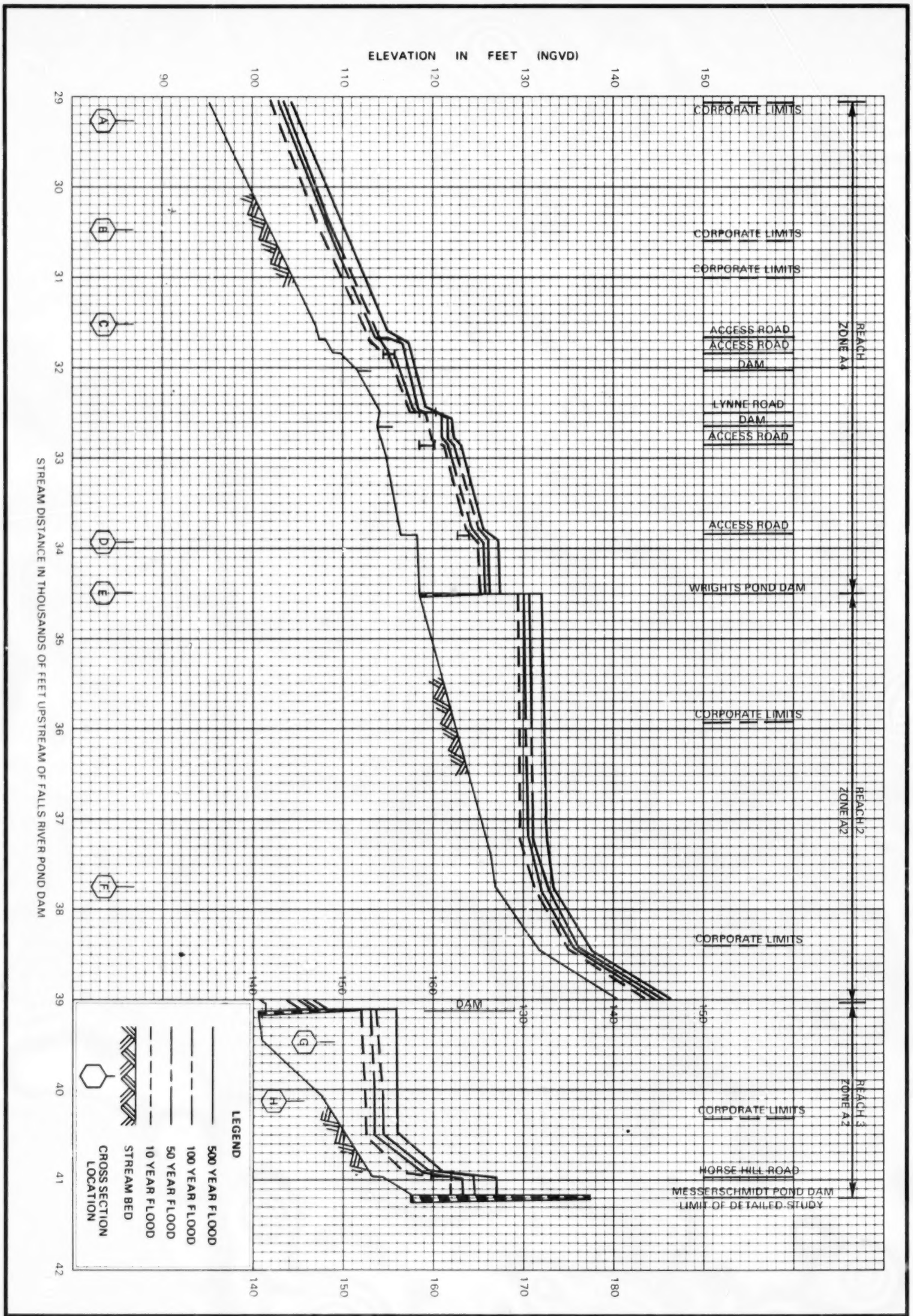

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WESTBROOK, CT
(MIDDLESEX CO.)

FLOOD PROFILES

FALLS RIVER

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